Government of Canada | Gouvernement du Canada
Canadian Forestry Service | Service Canadien des forêts

ISSN 0820-8107

NO. 164

# Canadian Forestry Service-Maritimes

# TECHNICAL NOTE

## ENERGY CONSERVATION IN GREENHOUSES. II ECONOMICAL PHOTOPERIODIC LIGHTING METHODS

Electricity costs in the Maritimes are high because they are partially tied to the cost of oil. In winter-greenhouse culture a small but significant cost of production can be attributed to the electricity used for photoperiodic lighting. To reduce electrical costs current practice is to interrupt the dark period, using 1-2 h of low intensity light (200-500 lux), in contrast to the previous practice of extending the day length to 14 h or more. The types of night-break lighting are diverse, ranging from mobile (irrigation cart-mounted) systems to strings of incandescent bulbs placed permanently over the growing area. This note discusses some techniques of night-break lighting, compares costs, and describes a low-cost moving fluorescent system developed and tested at Canadian Forestry Service - Maritimes (CFS-M).

### Photoperiodic Lighting Methods

Two types of lighting installation have evolved for greenhouse use: fixed and moving. The examples discussed here apply to a 10 x 30 m Quonset greenhouse, but are easily adapted to other greenhouse styles and sizes.

The oldest and most common form of fixed lighting uses 60 or 100 W incandescent bulbs spaced at 1 to 1.5 m intervals suspended in four strings above the crop. Permanently mounted lines of fluorescent lamps have also been used, and more recently some west coast facilities have mounted 400 W high pressure sodium (HPS) lamps on the endwalls.

An irrigation cart can be used to move a small number of lights back and forth across the crop for 1-2 h, nightly. Thus a low wattage system can serve the lighting needs of a large growing area.

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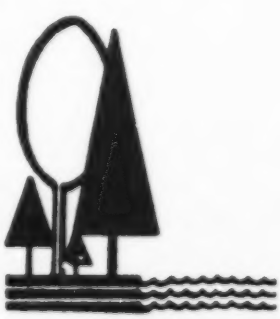

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Incandescent lamps (sixteen, 100 W bulbs per cart) are used operationally at one facility. A second cart-mounted system that has been operationally tested at CFS-M and elsewhere uses three 8-ft internally reflectorized, very high output (VHO) fluorescent lamps. An Ontario nursery has proposed the mounting of two HPS fixtures on the irrigation booms.

## Electrical Costs

A small industrial user such as a nurseryman is charged for electricity in a different way than a homeowner. The cost is a combination of two charges. The first is for "peak demand." A meter is used to record the kilowatt consumption averaged over a short period (15, 30, or 60 minutes). The maximum value recorded each month is used as the multiplier to calculate the demand charge. The second charge is for consumption. However, in contrast to the domestic rate, where a user is charged a fixed price per kilowatt-hour used, the industrial rate varies in some provinces with a higher rate being paid for the first block of consumption than for a subsequent block. High peak demand directly affects this charge rate, since the amount of consumption that is charged under the higher (first block) rate is calculated on the basis of the monthly peak demand charge. Current power rates for the three Maritime provinces and some sample calculations are included in Appendix A. In all three provinces high peak demand costs the user directly, and in Nova Scotia and Prince Edward Island it influences how much of the energy consumed is charged at the higher initial rate.

Table 1 gives estimates of the electrical usage for the various light systems. Including the conventional string lighting (static incandescent) for comparison, the operating costs for all three irrigation cart-mounted types have been calculated on the basis of consumption only (similar to the amount a residential user might pay), and with a peak demand calculation added. "Consumption only" reflects the cost added to the electrical bill assuming that peak demand occurred at some other time of the day, and that overall consumption was sufficient to exceed the first block consumption limit. The inclusion of peak demand calculation assumes that the lights are on at the same time as other greenhouse energy consumers (boilers, fans, unit heaters etc.), and therefore contribute directly to the peak demand charge as well as the second block energy charge. Most nursery operators could be expected to have costs in between these two extremes.

## A Mobile Fluorescent Photoperiodic Lighting System

A mobile fluorescent system was designed and has been tested for several years under operational nursery conditions. Fluorescent lighting has some distinct advantages for low-intensity dispersed lighting: the lamp is linear rather than being a point source which requires an expensive reflector. The system is inexpensive and can be homemade yet electrically safe.

Because no commercially available fixture could be found, we designed a fixture (Fig. 1) that can be built at the nursery. It can be made largely from locally available materials, or items easily ordered through an electrical supply house. This mounting system should meet most local electrical codes.

Table 1. Estimated monthly running costs for different lighting systems used for photoperiod control

| System type | Peak demand (kW) | Energy use (kWh)[2] | $/Month[1] Consumption only N.S. | Consumption only N.B. | Consumption only P.E.I. | Peak demand included N.S. | Peak demand included N.B. | Peak demand included P.E.I. |
|---|---|---|---|---|---|---|---|---|
| Incand. (static) | 9.60 | 576 | 27.24 | 28.92 | 54.62 | 84.36 | 98.33 | 105.14 |
| Incand. (mobile)[3] | 1.44 | 87 | 4.11 | 4.36 | 8.24 | 12.73 | 14.84 | 15.87 |
| HPS (mobile)[3] | 1.21 | 73 | 3.43 | 3.64 | 6.88 | 10.62 | 12.38 | 13.25 |
| Fluor./VHO (mobile)[3] | 0.95 | 57 | 2.71 | 2.87 | 5.45 | 8.36 | 9.74 | 10.45 |

[1]Includes a 17% discount for Prince Edward Island.
[2]On the basis of 2 h/night for 30 days.
[3]Includes the wattage used to run the irrigation cart.

**Fig. 1. Two fluorescent fixtures mounted back-to-back on an irrigation cart boom.**

The two ballasts required for the three fluorescent lamps are located on the irrigation cart, enclosed in a small panel box (Busway no. 3096 splitter box, or equivalent, measuring approximately 24 x 6½ x 6½ in.). (A 24 ft-wide greenhouse would require only two lamps, and therefore only one ballast.)

Figure 2 shows a diagram of a lighting system where each fluorescent socket (1) is mounted independently. This allows easy adjustment on the irrigation boom (9). Each socket is attached to a short piece of aluminum angle (5) using the rubber gasket (4) included with the socket to prevent water from entering a small connector box (8) mounted on the underside of the angle with the same screws. One or both sides of the connector box (only one side if the socket is at the end of the boom) are punched to accept a standard waterproof fitting (7). All wiring is run from socket to socket using flexible vinyl-coated conduit (6). The complete assembly is mounted on the irrigation boom using a muffler clamp (10). After adjustment, a lamp (2) is inserted between two sockets, and upon tightening the collar on the socket, a gasket (3) tightens on the fluorescent tube, excluding moisture from that connection point as well.

The fluorescent lamp suggested for the system is a very high output lamp. The internally-reflectorized version, which incorporates a white coating on the upper portion of the inside of the lamp, is used to direct more of the light onto the crop surface.

**Operational Considerations - Fixed vs. Mobile Systems**

Although string lighting is a cheap and simple system to install, frequent relamping throughout the growing season is required, because incandescent bulbs have a relatively short service life (1000-2000 h), which can be further reduced by condensation dripping from the cover onto the hot bulbs. Maintenance is inconvenient because the lights are permanently mounted over the centre of the growing area, whereas the mobile systems can be serviced from the ends of the benches. It should also be noted that this system may be hazardous, at least in home-built installations. The screw-on sockets commonly used are not waterproof, and aluminum foil pie plates are often added as refectors to direct light downwards onto the crop, and to protect the bulbs from condensation. Electrical shock is therefore possible from touching either the socket or the reflector.

The irrigation cart is a weak point of all of the traveling systems. The mechanically-reversed transmission wears after 3-5 years, resulting in a dead spot that stalls the cart at one of the end stops. If portions of the crop remain unlit for 2-5 nights before the problem is found, dormancy initiation and loss of growth can result (Arnott 1985). This problem will disappear as existing systems are replaced with newer models, in which the motor direction is electrically switched. If lights are mounted on the irrigation boom, it it important to ensure that the end-stops are firmly attached so that the cart does not accidentally run off the end of the rails, breaking expensive light fixtures. It is inadvisable to use nylon sleeve bearings (present in some of the older irrigation carts in the region) instead of high quality roller bearings

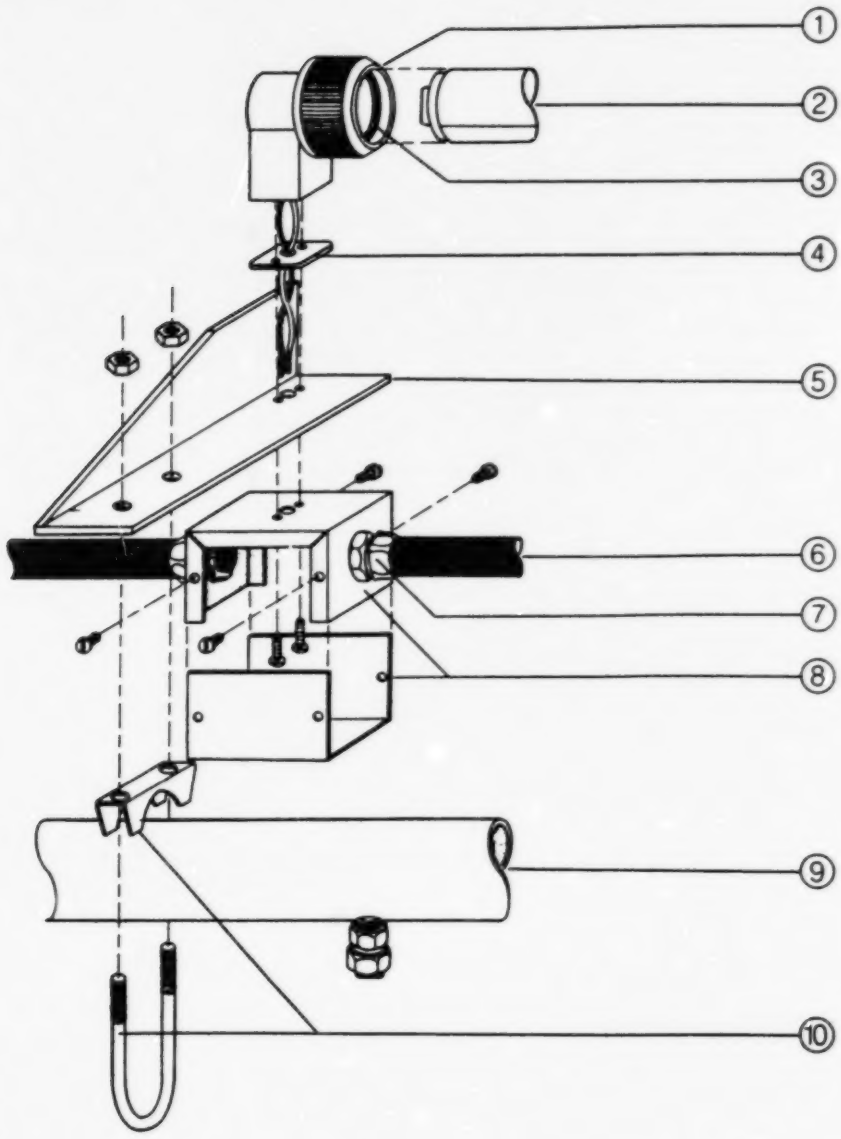


Fig. 2. Diagram of a fluorescent fixture for mounting on an irrigation cart boom: (1) Sylvania SA3283-VS (or SA3283-VT) fluorescent lamp socket (socket information courtesy of T.J. Mullin, N.S.L.F. Tree Breeding Centre, Debert, N.S.); (2) FR96T12/VHO/CW internally-reflectorized fluorescent lamp; (3) rubber lamp gasket; (4) fixture base sealing gasket; (5) 1/8" x 2" x 2" aluminum angle; (6) 3/8" Conseal vinyl-covered liquid-tight conduit; (7) waterproof box connector; (8) Hammond 1411B utility case; (9) irrigation boom; (10) muffler clamp.

in the pillow blocks that attach the axles to the cart. The nylon bearings wear quickly because of the extra weight of ballasts (if used), and the tendency of the cart to sway from side to side if heavy fixtures are placed well out on the watering booms.

Lamp replacement must also be considered, especially in large nurseries where lamp failure may be undetected for several days. Because a single lamp lights a large portion of a greenhouse when a mobile lighting system is used (or in the fixed stadium light system used in British Columbia) a long-lived type of lamp should be used. It is preferable to relamp a facility well before the rated burning life of the lamps is reached so that all lamps are of similar age and therefore equally dependable. As a result, lamp costs should be considered (see Table 2).

Table 2. Service life and replacement cost for different lamps used for photoperiod control, in static or mobile systems

| Lamp type | Wattage | Avg. rated life (h) | Cost/lamp ($) | Cost/greenhouse ($) | Replacement time |
|---|---|---|---|---|---|
| Incand. (static) | 60 | 2500 | 1.30 | 156.00 | yearly |
| | 100 | 2500 | 1.30 | 156.00 | " |
| Incand. (mobile) | 100 | 2500 | 1.30 | 20.80 | yearly |
| HPS (mobile) | 400 | 24,000 | 94.00 | 188.00 | 5-7 yr. |
| Fluor./VHO (mobile) | 215 | 10,000 | 12.80 | 38.40 | 5-7 yr. |

The mobile fluorescent system has been operated for several years in both test and production runs*. No major failures or design faults have yet been encountered. It is economical, safe, and quite easily constructed. We have lighted a variety of species (pines, spruces, and larches) operationally, and the system fulfills the photoperiodic requirements adequately.

**References**

Arnott, J.T. and C.S. Simmons. 1985. The effect of failure in extended and intermittent photoperiodic lighting on the growth of white spruce container seedlings. Can. J. For. Res. 15:734.

S.I. Cameron
October, 1986

*We wish to acknowledge the cooperation of the NB DNR&E Forest Nursery at Kingsclear, N.B.

**Appendix A**

Power rates for the three Maritime Provinces based on general service rates as of February 1986

| Type of charge | N.S. | N.B. | P.E.I.* |
|---|---|---|---|
| Demand charge | $5.95/kW/mo | $7.23/kW/mo (1st 20 kW - no charge) | $6.34/kW/mo |
| Consumption: | | | |
| 1st block: | | | |
| -calculation: | Demand x 100 | none: 5000 kW flat rate | Demand x 200 |
| -charge: | 9.37¢/kWh | 8.29¢/kWh | 12.57¢/kWh |
| 2nd block: (remainder) | 4.73¢/kWh | 5.02¢/kWh | 11.22¢/kWh |

*Subject to a rebate of 17% on the total bill until Oct. 1987.

A sample calculation for a monthly billing in each province based on 8 kW demand and energy use of 3500 kWh (excluding monthly service charges, if any):

**Nova Scotia:**

Demand: 8.0 x $5.95 = $47.60
Energy:
-1st block: (8.0 x 100) x $0.0937 = $74.96
-2nd block: (3500 - (8.0 x 100) x $0.0473 = $127.71
Total: $47.60 + $74.96 + $127.71 = $250.27

**New Brunswick:**

Demand: (8.0 - 20) < 0 (no charge)
Energy:
-1st block: 3500 x $0.0829 = $290.15
-2nd block: (3500 - 5000) < 0 (no charge)
Total: $290.95

**Prince Edward Island:**

Demand: 8.0 x $6.34 = $ 50.72
Energy:
-1st block: (8.0 x 200) x $0.1257 = $201.12
-2nd block: (3500 - (8.0 x 200)) x $0.1143 = $217.17
Total = $50.72 + 201.12 + 217.17 = $469.01; less 17% = $389.28